The U.S. Coast Guard battles the flames and smoke that spew from the barge Ocean 255 near the mouth of Tampa Bay after it and another barge collided with a freighter. As a result of the collision, contractors and more than 800 workers and volunteers were mobilized to clean up oiled beaches near Treasure Island and St. Petersburg Beach (inset).
Photographs and maps courtesy of the Florida Marine Research institute

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GIS Tackles Oil Spill in Tampa Bay

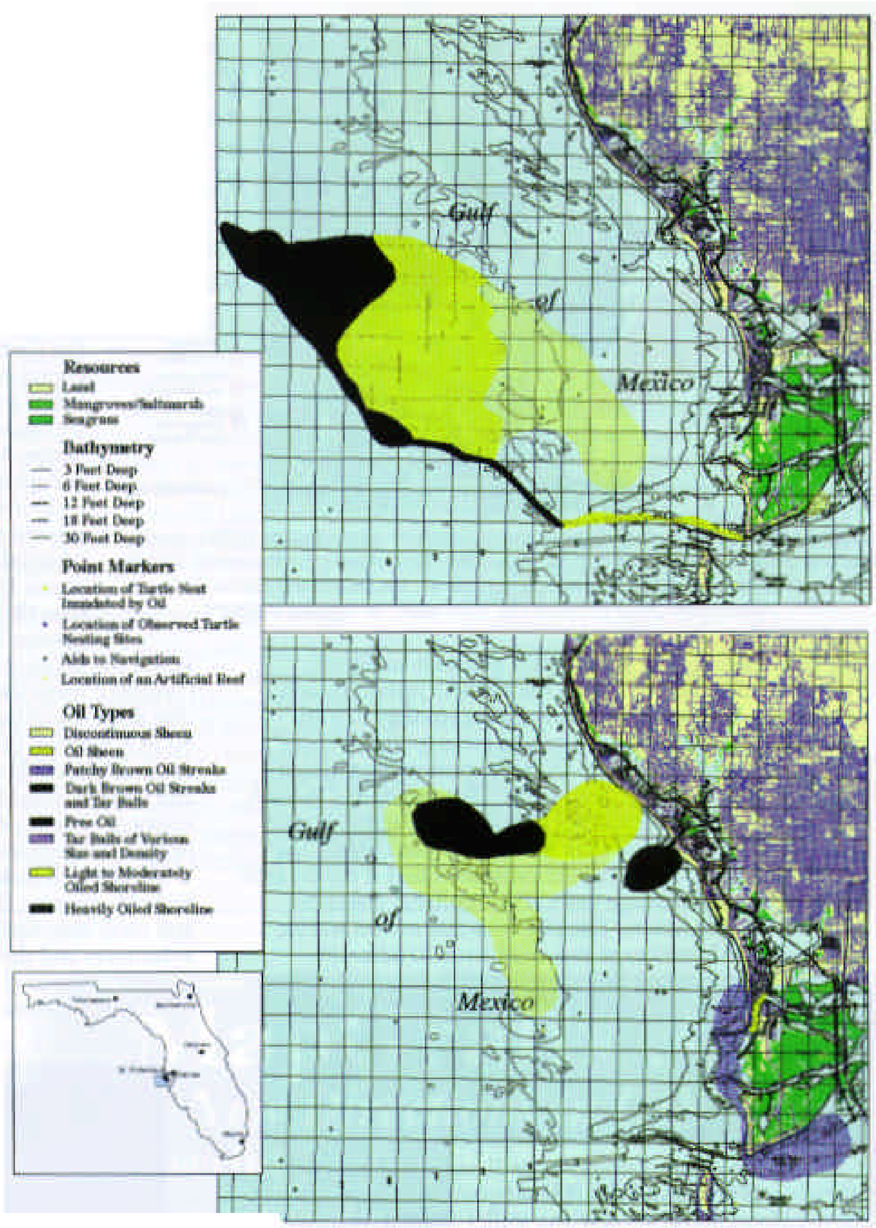
On Aug. 10, 1993, an outbound freighter, Balsa 37, collided with two inbound tugs, Seafarer and Fred Bouchard, near St. Petersburg, Fla., USA. Seafarer's barge, Ocean 255, burst into flames and burned for more than 14 hours before fire fighters on local government and Coast Guard vessels managed to control the blaze. Ocean 255 carried 188,000 barrels (7.9 million gallons) of Jet A fuel, kerosene-type fuel used in jet turbine engines. Fred Bouchard's barge, B-155, lost an estimated 388,000 of its 5 million gallons of No. 6 fuel oil – a thick product used for industrial heating – before the leaking stopped. Balsa 37, a bulk carrier transporting phosphate, also suffered damaged and took on water. The leaking chemicals moved with the tides toward some of Florida's most ecologically sensitive habitats and popular beaches.

Fortunately, recent organizational changes and technological advances enabled Florida agencies to respond to the catastrophe in an unprecedented manner. Several divisions and bureaus of the Florida Department of Environmental Protection (DEP) teamed with federal, state and local agencies to handle the emergency. GIS and global positioning system (GPS) technologies played important roles. Immediately following the initial spill report, the DEP Florida Marine Research Institute (FMRI) used its Marine Resources GIS (MRGIS) and GPS units to analyze changing spill conditions, logistical alternatives, resources at risk and environmental sampling strategies. Since early 1992, Florida's DEP has been designing a GIS application to help manage spills; this accident near the mouth of Tampa Bay provided the ultimate test of the application's design.

Anticipating Trouble

After the catastrophic Exxon Valdez spill in Alaska in 1989, the governor of Florida convened a task force to evaluate Florida's spill-prevention and cleanup capabilities. One task force recommendation focused on the short comings of the maps intended for use in oil-spill response. The only available maps targeting such spills were the "Sensitivity of Coastal Environments and Wildlife to Spilled Oil in Florida" series, developed in 1979-80. The atlases consist of 7.5-minute U.S. Geological Survey (USGS) topographic maps annotated with Environmental Sensitivity Index (ESI) shoreline types, wildlife-resource areas, and spill-response staging areas and strategies. The ESI ranking of shorelines is critical because it cartographically indicates the vulnerability of specific shorelines to oil spills.

The task force recommended that DEP review existing ESI atlases and update and integrate the information into a GIS to facilitate more frequent updates and real-time analyses. The Coastal and Marine Resource Assessment (CAMRA) group at FMRI was selected to implement the ESI effort. One of the institute's mandates is to provide the DEP Office of Coastal Protection with the capability and technical support to facilitate oil-spill contingency planning, response and damage-assessment responsibilities.



Media reports stated Tampa Bay 'dodged a bullet' as the oil slick expanded and floated out to sea (top). Changing weather conditions, however, drove the spill ashore near Johns Pass, Fla. (bottom). Almost 15 miles of beach were blanketed with tar.

Designed for Response

In 1992, CAMRA received a legislative appropriation to develop an "automated marine spill sensitivity atlas." After soliciting proposals, the group contracted with the Environ mental Systems Research Institute, Inc. (ESRI) Application Development Group, Redlands, Calif., USA, in June 1992 to initiate development of the Florida Marine Spill Analysis System (FMSAS). The principal goal of the project was to design an application that integrates a variety of information (digital maps, imagery and tabular data) with targeted analytical routines needed to implement an oil-spill response strategy focused on resource protection. Additional requirements were to implement a selected set of these conditions for a pilot study area in the Florida Keys and to develop a strategy for expanding the prototype to a state wide, operational system.

At the onset of the project, ESRI conducted interviews at FMRI with various representatives from selected agencies involved in marine spill management in Florida and the United States, including the National Oceanic and Atmospheric Administration (NOAA), the Marine Spill Response Corp. and the Coast Guard. The interviews were held during a week-long "rapid prototyping" workshop in which the existing application software and geographic databases developed by ESRI for other spill management groups in the United States and abroad were used. The premise of the rapid-prototyping approach was that marine spill requirements are similar from place to place and that using information gained from past efforts would help the workshop participants visualize the proper form and content for FMSAS.

The needs expressed during the rapid-prototyping process helped to determine the functional requirements of and basic format for the FMSAS database design. In addition, the needs assessment and database and application designs determined data requirements and guided a thorough inventory and evaluation of coastal data available in Florida.

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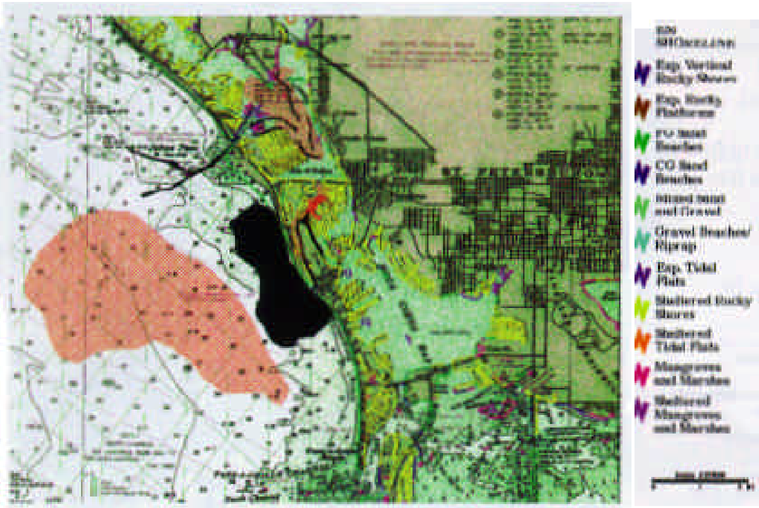


Scanned and rectified National Oceanic and Atmospheric Administration (NOAA) nautical charts provided a familiar base map for responders. By overlaying Environmental Sensitivity Index rankings and the changing spill boundaries, the Coastal and Marine Resource Assessment group provided vital information for decision makers.

These exercises helped design the FMSAS prototype and develop the statewide implementation strategy to fully extend FMSAS in functionality and geographic coverage.

Several tests helped keep the rapid prototyping design process centered in the "real world." For example, CAMRA was contacted by a consultant developing a facility contingency plan for a large oil tank near Boca Chica Naval Station in Key West, Fla. The plan estimated that if the oil tank ruptured it could damage natural and cultural resources within a 30-mile radius. The plan was due in two weeks, and the FMSAS prototype was used with 10 different databases – including data on marinas, habitats, and threatened and endangered species – to generate a resource-at-risk report. Lessons learned from this and other exercises were used to further refine the evolving FMSAS design and prototype.

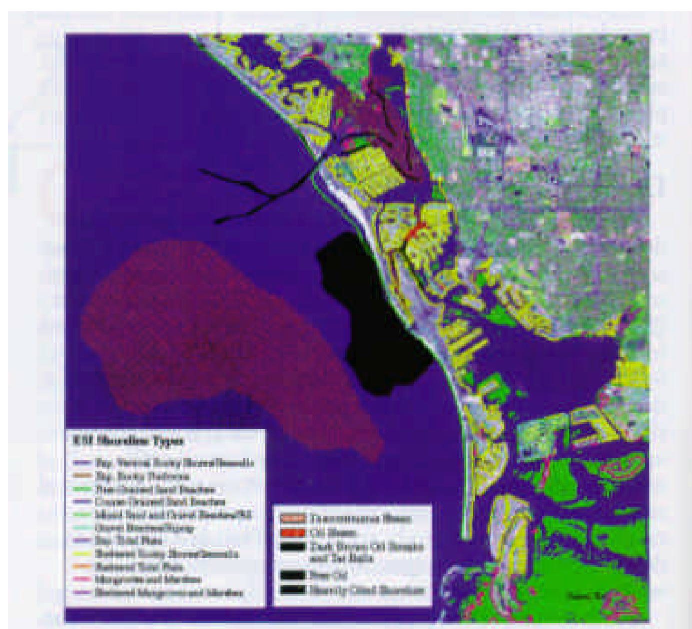
Rapid Response

In the case of the Tampa Bay spill, state and federal officials and private parties reacted quickly in containing the oil. Upon notification of the spill, CAMRA analysts were split into two teams. One team began producing maps using MRGIS while the other began altering the prototype FMSAS so it would be applicable for Tampa Bay as well as the Florida Keys. CAMRA's initial role was to provide responding agencies with maps depicting existing natural and cultural resources relative to the predicted path of oil movement. Responding state and federal agencies wanted detailed information on the bay's natural resources – bathymetry, sea grass beds, mangroves, marshes, turtle nesting and endangered wildlife sites, etc. – displayed in conjunction with the current location and extent of the spill. CAMRA combined many data resources to provide maps for simultaneous evaluation and monitoring aspects of the response efforts. At each step, the teams had to anticipate how map requirements would change as spill conditions changed. To meet those requirements, they had to acquire and integrate necessary data that were not already in MRGIS.

To assimilate spill-boundary information in near real time, the institute used the GPS resources of its Marine Mammals Section (MMS). MMS staff used GPS receivers from helicopters to record locations of the vessels and the changing perimeter of the spill. The GPS files were imported immediately into MRGIS and incorporated into maps. The first map was plotted just hours after the spill occurred and was hand-carried to the Coast Guard command center so each agency could formulate its response plans. Maps produced during the first three days were considered critical aids in developing possible scenarios at the Coast Guard command center. The helicopter-based GPS crew collected data several times a day throughout the project. As the spill continued, air-to-plot time decreased to just 3.5 hours. Maps more than five hours old were considered "out of date."

During the first days after the spill, media reports gave the impression that Tampa Bay "dodged a bullet," because the oil was floating out to sea. However, changing weather conditions soon drove the oil back toward John's Pass, a passage into Florida's Intracoastal Waterway. When the oil slick was "migrating," relatively small-scale (1:60,000) maps showing shoreline, islands, aids-to-navigation and critical habitats were most appropriate. Scanned NOAA nautical charts (250 dots per inch) were rectified and used as a valuable visual base map to actual spill boundaries and natural resources. The Coast Guard, NOAA and state response officials specified these nautical charts to be used because all responders were familiar with the basic format.

As the spill neared land and washed ashore, the type and scale of mapping changed. Maps with ESI shoreline rankings and more annotation were required to coordinate the 800 volunteers and the contractors coming from around the state to assist in cleanup efforts. The maps included information such as road networks, navigational aids and the



The Coastal and Marine Resource Assessment group integrated a variety of spatial data to respond to the spill. Landsat Thematic Mapper satellite imagery provides collateral information to verify Environmental Sensitivity Index rankings.

locations of temporary rescue headquarters such as schools and municipal buildings. Scanned USGS quadrangle (1:250,000 and 1:24,000) images were rectified and used as base maps to provide maximum annotation quickly. The various databases and images were combined to create different maps: those showing the changing locations of spill boundaries and resources at risk were used by command center staff, the media and field workers, while those showing information necessary for determining environmental sampling strategies were used by individuals involved in response and damage assessment.

GIS Community Assistance

Assembling the data needed to conduct the analyses and mapping required the collective efforts of several agencies and companies. On short notice, a variety of organizations mobilized to help FMRI respond. ESRI sent a GIS analyst to FMRI for three days to help convert data, create maps and document future design considerations for FMSAS. Geonex Corp., St. Petersburg, created the scanned images of NOAA navigational charts, USGS quads and other documents used as visual backdrops.

Marine Spill Response Corp., Washington, D.C., USA, and Research Planning Inc., Columbia, S.C., USA, provided additional support by releasing and delivering preliminary files of Tampa Bay's ESI shoreline just 48 hours after the spill occurred. The ESI shoreline rankings were plotted over the canned 1:24,000 USGS maps and Landsat Thematic Mapper satellite imagery to produce "value-added" response maps. A total of 2,500 feet of maps were plotted during the spill. When supplies ran out on a Sunday, the U.S. Fish and Wildlife Service National Wetlands Inventory office in St. Petersburg provided electrostatic plotter paper.

Development Directions

The question of whether GIS can contribute to oil spill management was answered in Tampa Bay. Many of the lessons learned during the recent spill will be used to further refine the conceptual design and physical characteristics of FMSAS. Assumptions made during the design process were tested in a crisis setting. To focus future refinements, FMRI will hold a debriefing of involved parties to identify functions FMSAS performed well and those that need enhancements.

The FMSAS full-scale implementation report prepared by ESRI described a long-term plan for the incremental development of a statewide, GIS-based oil spill response system for Florida. The plan prioritizes key databases. The challenge is to assemble and automate the data for each region of the state before a spill occurs there. Several paths for extending FMSAS functionality also were included in the plan. DEP is exploring the possibility of cooperative agreements with other agencies and organizations to foster a collective investment so FMSAS can be shared and improved without redundant expenditures. The long-term goal is to continue FMSAS development to provide greater protection for Florida's natural resources.

Acknowledgments

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